Hypothesis of Primary, Secondary and Tertiary Agonists of the Mpemba Effect

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Introduction

Although the so-called Mpemba Effect (which might more appropriately be known as the Aristotle Effect as Aristotle was, in fact, the first to observe it) has been studied for 2400 years, the dynamics which cause hot water to freeze faster despite having a higher starting temperature when exposed to a cold environment are still debated. Although this author's proposed primary explanation is relatively simple, there may be effects secondary as well as tertiary to the primary cause of this rapid cooling with ramifications for high-efficiency cooling efforts.

Abstract

The Mpemba Effect may be primarily explained by the induction of convective currents in fluids which have their mechanical origins in the differential between the temperature of the surrounding environment and the temperature of the liquid. Once convective currents of various scales are initiated by this differential, fluid convection continues with little friction under its own momentum even after the temperature of the fluid approaches equilibrium with the surrounding environment. Convection is enhanced due to a tendency for a large macro current to be generated in a body of fluid which begins as a series of smaller rotational currents. After the initiation of a macro-scale current, the macro-scale currents feed back into smaller scale currents located near the boundaries of the body of fluid, particularly in areas of more pronounced thermal gradation. The interplay between larger and smaller currents enhance thermal conduction and allow for symmetrical freezing of fluids over wide areas (whereas without these smaller eddies, the water on the surface of a lake would tend to freeze at the center of the lake (i.e. it is nearer to the primary current) before freezing at the edges rather than vice versa.)

The most prominent source of heat diffusion in Mpemba is conventional fluidic convection at various scales. However, heat-diffusion is a multi-dimensional process. Not only has heat-induced convectional momentum been underestimated by physicists, at least two other unseen effects are, in the opinion of this author, at play. It should be noted that individual water molecules have rotational energy which can be converted into thermal energy. Molecular spin of water molecules may offer an explanation of the 'latent heat' phenomenon seen in sodium acetate-based re-usable hand-warmers. When phononic energy is introduced to such a hand-warmer, I propose that what is actually happening is that rotational energy (frictionless) is converted into heat energy when generates a cascade in which that rotational energy ceases to be frictionless and in which some of that rotational energy is converted into conventional thermal energy (motion of the nucleus of the atom in excess of the motion of its electron cloud leading to increased molecular motion.) However, this is not the only non-primary conduction-enhancing effect at play.

If the rotation of fluids on the macro scale is the primary driver of enhanced cooling effects in the Mpemba effect and the rotation of individual water molecules is a secondary catalyst of heat conduction is secondary, then I would nominate something which may be termed a synergy between nuclear motion and molecular motion as a latent conductive catalyst.

I propose that when optimized thermal gradients are created, particularly when a body of water is cooled from two opposing sides (but not from all sides simultaneously or from two adjacent sides for reasons which I will endeavor to explain,) nuclear oscillation may synergize with the overall molecular motion of water. Comparatively large zones of the fluid may feature, under the condition of an idealized gradient, synchronized nuclear motion between many molecules. These areas of synchronization, when realized, could be predicted to move as waves and periodically lapse between synchronicity and asynchronicity. This synchronicity results in the generation of infinitesimal quantities of quantum acoustic energy which enhances the conduction of heat. To put it another way, when hot water mixes with either cold water or cold air, it generates its own sound. As water has its own unique properties and therefore its own unique resonance frequency, water's properties dictate that there is an optimal thermal gradient which will generate these phononic waves more efficiently. Too great of a gradient or too little of a gradient mitigates the effect to the point whereas it could easily avoid detection.

We may test this hypothesis by measuring the length of time it takes to chill a vessel of water within a perfect cube by chilling the cube from two out of six sides in different combinations. This author proposes that chilling will be more efficient when the cube of fluid is chilled from two opposing sides than in the case that is chilled from two adjacent sides. As the surface area through which heat is diffusing is the same, conventional wisdom holds that the rate of thermal dissipation should be the same regardless of which two sides contact a chilling plate. If the experiment shows that chilling plates on opposing sides of the body of water bring about more rapid chilling than chilling from adjacent sides, this indicates that an unseen cooling effect is at play and that the hypothesis is deserving of further investigation.

Conclusion

If we wish to develop a bespoke and optimized heat-diffusion system for any application, we ought to begin considering the secondary and tertiary contributors to the Mpemba Effect as delineated by this author. Maximally efficient heat diffusion must include the introduction or induction of quantum phononic waves. As the introduction of additional acoustic energy may contribute to heating, control over thermal gradients relative to fluid density may be used to ensure that the needed energy is self-generated. Furthermore, when cooling is achieved through a cylindrical pipeline, this effect may be unwittingly mitigated by the shape of the pipeline and the tendency of cooling to proceed in all directions. Counter-intuitively, cooling pipelines in the form of rectangular prisms in which cooling may proceed in two opposing directions but in which the remaining sides of the prism are insulated may be more efficient in supporting cooling both because heat energy may be directed into a greater "heat siphon" network and because the

aforementioned nuclear-molecular locomotive synergy is optimized by linear thermal gradients and is frustrated by omni-directional gradients, which ought to be avoided in any such regime.